Space Weather Technical Forecast

Issued on Thursday, 10 March 2022 at 13:06 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1 to end current working week and again late in the weekend (UTC). Daily Chance of R1. Continuation of Active Electron fluence becoming less assured.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low over the period, with a solitary marginal C1.0 flare observed at 09/1249UTC from the largest and most complex region on the disc, AR2965 in the northeastern quadrant. This spot showed development in its intermediate spots and overall growth, ending the 24 hours as a Fai/Beta-Gamma, perhaps also trending towards a compact designation. This was one of up to six sunspot regions on the disc at present.

The other main area of development was in the southwestern quadrant, with an apparent latent 'upwelling' resulting in growth of AR2964 and AR2966. These groups eventually developed in Dao or perhaps now Dai/Beta; and also Bxo/Beta respectively, but with no associated X-ray activity. These groups developed around a small island of negative flux on HMIBC imagery in a belt that was otherwise strongly positive, in what appears to be a starkly-polarised solar quadrant.

This is in contrast with much of the western solar hemisphere, which is markedly more diffuse, to the point that the polarity of CH65 is not even clear at the time of writing. The one large exception to this general trend was, however, the area surrounding AR2965.

The remaining sunspot groups on the front side were all stable or in decay, including AR2960 which areally dominates centre-disc, but appears to be spreading and consolidating into a simple Eho/Beta, with a trend toward only the leader surviving as a Zurich Hhx.

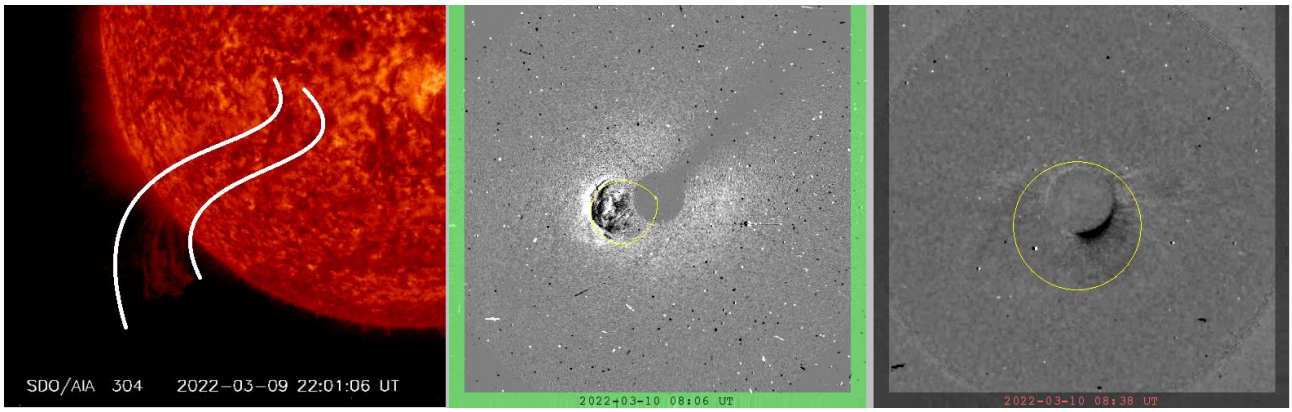

Figure 0: AIA 304 image of late UTC evening southeastern quadrant filament lift-off. Also shown are running difference coronagraph images of the ensuing CME from a Lasco C3 (centre) and STEREO A COR2 (right) perspective. Counter to expectations, this CME does potentially bear an Earth-bound component, perhaps because of the way it interacts with the CIR leading CH65, although the chances of G1 are considered very small.

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There remain numerous - mostly small - filaments on the disc at present. The largest of these lifted off the southeastern limb late in the UTC evening of 09 March, with the resultant Coronal Mass Ejection (CME) clearly discernible in coronagraphs into the current UTC day. This event has been modelled, and counter to expectations does in fact show marginal influence is possible at Earth from at least the shock at the very end of the four-day period. This is therefore now one of up to three CMEs in the forecast.

Solar Wind / Geomagnetic Activity: The solar wind was reflective of a slow regime, perhaps with the last vestiges of CH62/- apparent right at the start of the 24 hours. The solar wind speed accordingly fell, as measured by DSCOVR at L1, reaching Background levels of near 375km/s from a starting point of near 425. The solar wind density conversely showed a slight rising trend, although remaining well within single figures ppcc throughout. The IMF was level - at or slightly below 6nT, however the north-south component spent protracted amounts of time anti-aligned with Earth's field, with a nadir of -5nT versus a very brief +2nT co-aligned. The phi angle was erratic, but more often negative (towards the sun), especially before 09/1600UTC.

The net result of the above solar wind measures was nevertheless provisionally Quiet through the 24 hours, with Kp at or below 2- throughout.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at Background levels.

The high energy electron flux (greater than 2 MeV) was High throughout, with a peak value of 5130pfu at 09/1500UTC. The corresponding 24-hour integrated electron fluence remained above the Active (1e8 integrated pfu) level, with the 10/0000UTC observation being 2.58e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Expected to be Low, with further C-class flares, but with a daily Chance of rising to Moderate - the main risk being from AR2965, but perhaps also the southwestern quadrant areas.

Solar Wind / Geomagnetic Activity: No coronal hole high speed streams feature in this forecast period. There are now up to three CMEs en-route with a potentially Earth-directed component, all with low confidence. The first is from an uncertain source on 05 March; the second from a filament eruption late on 06 March; and the third the aforementioned 09 March southeast quadrant filament.

Any arrival(s) that occur are currently expected over the remainder of day one (Thursday 10 March) with ongoing influence possible during Friday; with a lull then likely ahead of a similar low confidence arrival late on Sunday 13 March.

In the absence of the CMEs, solar winds are expected to persist at background levels throughout the four-day period. This potentially may rise to Active, with a chance of G1/Minor Storm intervals with any CME arrival(s), as stated most likely occurring to end the working week, and perhaps again to round out the weekend.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, albeit with a very slightly above-background risk of rising towards the S1 level.

The high energy (greater than 2 MeV) electron flux is expected to be at High levels at first, but likely dropping out with any CME arrival(s), with fluence remaining Active for the time being.

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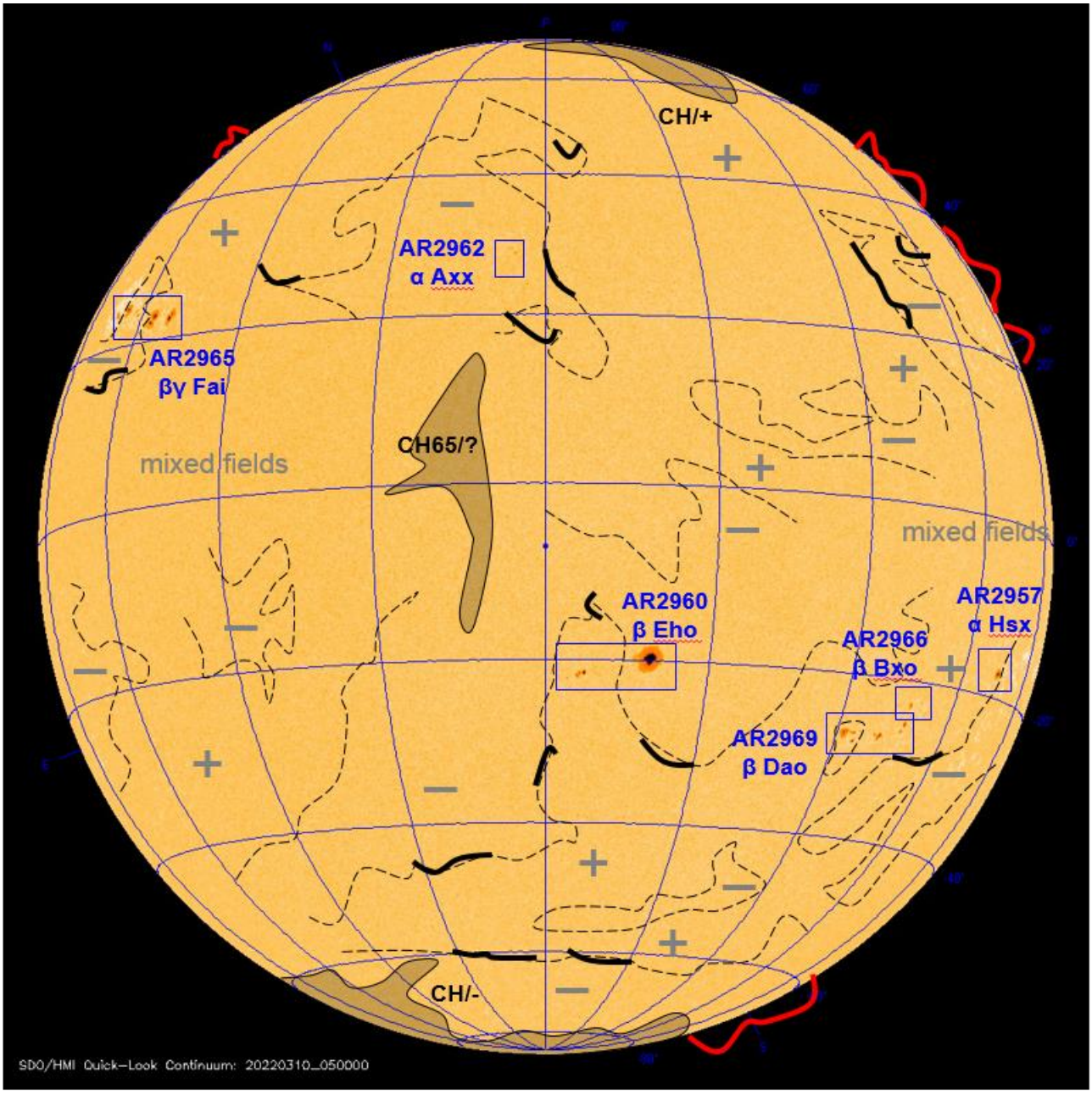
Confidence is now further reduced in behaviour of electrons beyond the immediate term, with successive low confidence CME arrivals mooted, although there still is a chance of Active fluence being maintained throughout.

Figure 1. Solar Analysis Valid 10/0500UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are now up to three Earth-directed CMEs in the forecast.

The first is a low confidence CME, due to only a weak signal in SOHO Lasco coronagraph imagery and an uncertain source, leaving the Sun on 05 March. The second was due to a filament eruption late on 06 March, and whilst confidence is higher on the analysis, it is lower for Earth-directed impact with only a glancing interaction due. These CMEs are indicated to arrive on day one (Thursday 10 March) - perhaps merging into a single arrival. The third CME is tied to the evening UTC filament lit off from the southeastern quadrant on 09 March. Despite being from an apparently too far eastward location, there appears to be a degree of interaction between this and the CIR leading the fast wind from CH65 to end the current four-day period, with the result that at least the shock may offer a slightly increased Slight Chance of G1 to round out the UTC weekend.

Confidence in the first two CMEs is increased due to news that the Solar Orbiter magnetometer has reported a direct hit from two CMEs whilst in the Sun-Earth line (reported on Twitter). Given a strong negative Bz-component of the IMF was observed, the risk for G1/Minor Storm intervals has been increased, with arrival expected in the second half of day one (10 March), and a potential magnetic cloud influence continuing through Friday 11 March.

In the absence of the aforementioned CMEs, background solar winds are expected, with the only coronal hole of note on the disc, CH65, not expected to bring any fast wind into Earth until perhaps narrowly beyond this forecast period. Mainly Quiet geomagnetic activity is therefore forecast. There is now a Chance of G1/Minor Storm intervals with any CME arrivals at Earth, most likely occurring before the end of the current working week UTC, but now also again at the end of the UTC weekend.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	30	5	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
05/1502	Partial	Unknown	15E 04N	224km/s	10/1200UTC	Very low confidence, could combine with below

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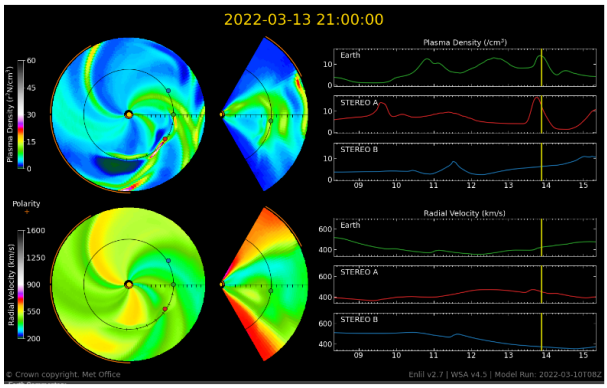
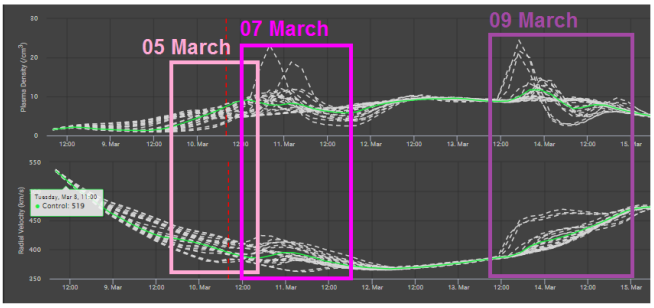
07/0920	Partial	Ex-2598 filament eruption	24W 10N	417km/s	12/2100UTC	Glancing blow expected
09/2300	Partial?	SE quadrant filament	36E 18S	445km/s	13/2300UTC	Possible shock, mainly outside period. Low confidence

Figure 2: Latest MOSWOC Enlil, with now up to three inbound CMEs modelled – the contribution of each shown boxed in the ensemble. All are either low confidence, of glancing incidence or both.





Radio Blackouts - X-Ray Flares:

There are currently six numbered sunspot regions on the visible disc, although solar activity has remained Low.

The most notable region is AR2965 Fai/Beta-gamma near the northeastern limb. This is an elongated collection of small spots, set amongst an area of plage that has shown some recent development, although this may be exaggerated due to the improving viewing angle. In the southwest disc, there is a further collection of small spots which form two separate but close regions AR2964 Dai/Beta and AR2966 Bxo/Beta, the latter of which only developed in the last 24 hours. Whilst small, these spots are both noteworthy due to a reverse polarity for solar cycle 25 southern hemisphere spots, such that any further development has the increased potential for instability that may result in flare activity. AR2960 Eho/Beta in the centre disc has the largest individual spot, with a large leader, but remains stable. The other regions, AR2957 Hsx/alpha and AR2964 Axx/Alpha are small and stable.

Low activity is expected to continue, with an 80% chance of further C-flares, and a Chance of increasing to Moderate with any M-flares.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	25	25	25	25
Very Active	**R3 to R5 X Class**	No	2	2	2	2

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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently at Background levels, with solar radiation storms not expected. However, the development of AR2966 near AR2964 in the southwest disc, both of which have an reversed magnetic configuration for solar cycle 25, gives a slightly above-background risk which is maintained through the period. This is also supported by the development of AR2965 in the northeast, although this is in a much less favourable location for any proton rich flare to result in radiation storms at Earth.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (2 MeV) electron flux as observed by GOES16 is currently at High levels, and is Expected to persist at these values until the arrival of any CME on day one (Thursday 10 March). The occurrence and strength of any arriving CME is low confidence, however if this occurs a drop-out in observed flux to background levels is expected. Any recovery is likely to be muted later day two, with a chance of Moderate to High flux levels returning from the UTC weekend onward. The chances of these levels persisting throughout the four-day period is now slightly reduced as a result of yet another marginal CME rounding out the forecast.

The associated 24-hour fluence is expected to persist at High levels to end the current working week UTC, due to the delayed response to the drop out caused by the 24-hour summation period. Through day two, Friday 11 March, fluence should most likely fall below this threshold.

REFM is currently poor guidance, as it is both underestimating current flux and is also by nature not able to take account of upcoming CME arrivals.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	90	30	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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